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Geographic isolation predicts tobacco product use among youth: A latent class analysis

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Abstract

Purpose: The purpose of the current study was to evaluate associations between geographic rurality and tobacco use patterns among adolescents.

Methods: High school students (N = 566) from north-central Appalachia reported on their lifetime and/or current use of cigarettes, electronic cigarettes (ECIGs), cigars, and smokeless tobacco. Geographic rurality was measured via the *Isolation* scale, whereby residential ZIP Codes determined the degree to which respondents have access to health-related resources. Latent class analysis (LCA) was used to identify discrete classes of adolescent tobacco users based on their use of tobacco products. Then, associations between participants' geographic rurality and class membership were evaluated using a series of multinomial logistic regressions.

Findings: LCA classified participants as Nonusers, Current ECIG Users, Cigarette/ECIG Experimenters, and Polytobacco Users. Individuals with higher Isolation scores were more likely to be Polytobacco Users and Cigarette/ECIG Experimenters than Nonusers, and were more likely to be Polytobacco Users than Current ECIG Users.

Conclusions: The continuous *Isolation* scale used in the present study predicted polytobacco use patterns among adolescents in a manner that is consistent with, while simultaneously expanding upon, prior work. Tobacco control practices and policies should be viewed through a lens that considers the unique needs of geographically isolated areas.

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Keywords

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Not all populations in the United States have experienced the steady decline in tobacco use observed over the past decade.[1] For instance, both adolescent and adult residents of more rural areas reveal significantly higher rates of cigarette and smokeless tobacco (SLT) use relative to their urban counterparts.[1-3] These rates are markedly high in areas considered most geographically isolated, such as Central Appalachia and the Deep South.[4,5] Nicotine addiction may also be more severe among those living in rural (vs nonrural) communities; rural adolescents begin smoking at younger ages[6] and rural adults tend to be heavier smokers.[7] Related to this inequality are multiple tobacco-related disadvantages experienced by rural populations, including weaker tobacco control policies, more positive cultural norms around tobacco use, targeted protobacco advertising, more barriers to health-promoting resources, and lower socioeconomic status (SES).[3,6,8-13] Given that rural residents carry a heavier tobacco-related health burden than do those from more urban areas, the US Food & Drug Administration has designated them as "vulnerable."[14,15]

Notably, these geographic patterns of cigarette and SLT use may not hold for other tobacco products. For instance, rates of water-pipe/hookah and cigarillo use are higher for adults in urban relative to rural areas,[16] whereas rates for cigars/pipes do not differ by area for adolescents or adults.[3,16,17] Findings regarding electronic cigarette (ECIG) use rates are mixed, with no differences between rural and urban adolescents or adults,[2,17,18] higher rates for urban (vs rural) adolescents who also smoke cigarettes,[2] higher rates for urban (vs rural) adult males but not females,[16] and higher rates for urban (vs rural) adults only in the northern and western regions of the United States.[19] Still, work that addresses geographic differences for these less traditional tobacco products is limited despite the staggering growth of their use in recent years.[8,20-22] Such work also is limited for polytobacco use (ie, the concurrent use of multiple tobacco products), which is common among both adolescent and adult tobacco users.[23-27] For adults, use of multiple traditional products (eg, cigarettes, SLT, and cigars/pipes) is associated with rural residence, whereas polytobacco use of alternative tobacco products (eg, ECIGs, cigarillos, and water-pipe/hookah) is associated with urban residence.[16] When traditional and alternative product types are combined, however, adult polytobacco use patterns do not differ as a function of geography.[16] For adolescents, polytobacco use may be more likely to occur for those residing in rural areas[17]; however, product type was not distinguished in this study (ie, any combination of traditional and/or alternative products was considered polytobacco use), making it difficult to elucidate specific patterns of polytobacco use. Clearly, more work is needed to address geographic disparities in these present day use patterns, particularly among vulnerable adolescent populations.

The purpose of the current study was to evaluate associations between geographic rurality and tobacco use patterns among adolescents. First, latent class analysis (LCA) was used to identify discrete classes of adolescent tobacco users based on their use of cigarettes, SLT, ECIGs, and cigars. Then, associations between participants' geographic rurality and class

membership were evaluated using a series of multinomial logistic regressions. Degree of geographic rurality was determined using the continuous *Isolation* scale,[28] which is based on participants' ZIP Codes and provides more variability than do other characterizations of rurality (eg, US Census, RUCA). Geographic isolation is a critical health-related characteristic of rural areas, which tend to be isolated from resources that support healthy living: basic infrastructure, employment, easy access to healthy food and health care, and reasonably good access to health-related information or products provided through internet services.[28]

METHOD

Participants

A convenience sample of adolescents (N = 566) was recruited from 4 high schools (n = 513) and one primary care adolescent medicine clinic (n = 53) located in north-central Appalachia (suburban Ohio, suburban West Virginia, rural West Virginia, and rural Pennsylvania) between fall 2015 and spring 2017. An attempt was made to recruit schools located in both rural and nonrural regions, while the medicine clinic allowed for continued recruitment into the summer months. This clinic services students primarily from 2 of the schools who participated in the study. Participants were 14-18 years of age (M_{age} = 15.95 years, SD = 1.16), currently enrolled in high school, and English speakers. The final sample consisted of primarily females (59.4% female) and White students (83.0% White vs 3.6% African American/Black, 4.1% Asian, 1.8% Hispanic/Latinx, and 5.5% Mixed race). Adolescents who exhibited significant cognitive impairment, as identified by teachers or clinic staff, were excluded from participating in the survey.

Procedure

All study procedures were approved by the university's Institutional Review Board, as well as the collaborating schools and medicine clinic prior to data collection. The initial visit to schools consisted of an introduction to the study (participation requirements, potential risks and benefits) by a member of the research team, followed by distribution of the invitation letters and assent/consent forms for students to take home to their parents/legal guardians. The second visit to schools occurred ~2-7 days after the first visit and involved collection of the signed consent forms. Those who consented to participate were asked to complete a variety of measures (eg, tobacco product use, risk behaviors, smoking expectancies, and self-efficacy). Participants completed all questionnaires via paper-and-pencil during regular class time; research staff were available to answer questions. At the medicine clinic, physicians screened for youth who appeared to meet inclusion criteria. For those who expressed interest in the study, research staff explained participation requirements and then obtained assent/consent from youth as well as consent from parents. Clinic youth completed the same packet of paper-and-pencil questionnaires as school-based participants, and in locations separated from their parents. Both students and clinic patients who completed all questionnaires were entered into a lottery drawing for the chance to win one of 40 gift cards at a value of $20 each. To reduce potential data entry errors, questionnaire data were transferred from paper into 2 separate SPSS (IBM Corp., Armonk, NY) data files by independent researchers.

Comparisons between the 2 data files were made and discrepancies were resolved prior to data analysis.

Predictors/measures

Student information form—This form contained questions regarding demographic characteristics, including age, sex (male or female), and mother/father education (used as a proxy for SES). For the latter characteristic, participants were categorized as having none (32.3%), 1 (23.9%), or 2 parents (42.4%) with a college education or higher. If participants reported on the education of only 1 parent, the education level of that single parent was used.

Tobacco product use—Measures of tobacco product use were derived from the Youth Risk Behavior Survey (YRBS). Lifetime use of cigarettes ("Have you ever tried cigarette smoking, even one or two puffs?") and ECIGs ("Have you ever used an electronic vapor product?"; examples, such as "Blu," "NJOY," "vaping pens," and "e-cigarette" were provided) was measured using a dichotomous scale. Adolescents provided an answer of "no" (classified as "nonuser") or "yes" (classified as "lifetime user"). Lifetime users were then asked whether they currently used a particular product: cigarettes ("During the past 30 days, on how many days did you smoke cigarettes?") or ECIGs ("During the past 30 days, on how many days did you use an electronic vapor product?"). Their answers to these latter questions were provided on a 7-point Likert scale that ranged from 0 (0 days) to 6 (all 30 days). Those who reported use of that product on at least 1 day of the past 30 days were considered "current users." Note that the YRBS does not assess lifetime use of other tobacco products.

Adolescents were also asked about their current use of SLT ("During the past 30 days, on how many days did you use chewing tobacco, snuff, or dip, such as Redman, Levi Garrett, Beechnut, Skoal, Skoal Bandits, or Copenhagen?") and cigar products ("During the past 30 days, on how many days did you smoke cigars, cigarillos, or little cigars?"). Answers were provided on the same 7-point Likert scale as that for cigarettes and ECIGs; youth were categorized as "current users" if they reported product use on at least 1 day of the past 30 days.

Isolation scale—All measures of rurality in common use in the United States capture the construct of geographic isolation, and do so with varying levels of precision (categorization) and at various levels of geography.[29] The *Isolation* scale[28] is a *continuous* measure of rurality based on the distance to populated areas and calibrated on the geographic distributions of health-related resources. It is calculated at the level of the US Census tract or ZIP Code. The continuous nature of the measure is valuable for this research because of the small area studied in which most measures of rurality do not provide sufficient variability. A detailed description of the calculation and validation of the *Isolation* scale is found in the work of Doogan and colleagues.[28] These researchers found that the *Isolation* scale was well correlated with other measures of rurality and it was a better predictor of all 3 health outcomes that were evaluated—infant mortality rates, national smoking-related mortality rates, and smoking quit ratios—than any of the most commonly used measures of rurality in the United States.

Analytic plan—All analyses were conducted using M*plus* 8.4.[30] Full-information maximum likelihood (FIML) was used to estimate missing data in all analyses. First, an LCA was conducted to determine classes of tobacco use among adolescents using the lifetime and current use categorizations described above. LCA is a person-centered approach that classifies individuals into groups based on their pattern of scores from a set of dichotomous variables.[31] The number of classes was empirically determined based on fit indexes, such as the Akaike Information Criterion (AIC)[32] and the Bayesian Information Criterion (BIC),[33] for which lower values represent more parsimonious models. Additionally, the Vuong Lo-Mendal Rubin LRT test was used to assess model fit. This fit index evaluates whether a model with *k* classes provides a significant improvement in fit over a model with *k*-1 classes. Finally, entropy values were considered in evaluating model fit. Entropy values range from 0 to 1, with values closer to 1 representing better classification quality. Starting with a 1-class solution, models were estimated with increasingly more classes until there was no further model improvement (ie, fit indexes show no substantive change or additional classes are small, conceptually unclear, or there are slight variations on already identified classes).[31]

Once latent classes were identified, univariate comparisons were made for *Isolation* scores, age, sex, and parental education across classes using chi-square tests for categorical variables and one-way ANOVAs for continuous variables. Tukey's Honestly Significant Difference post-hoc tests were used to follow-up on ANOVA findings that were significant. Then, multinomial logistic regressions were used to determine whether *Isolation* predicted class membership after accounting for demographic covariates (ie, age, sex, and parent education) and nonindependence introduced by nesting.

Due to lack of variability, race/ethnicity was not included as a covariate. To account for nonindependence introduced by nesting, a cluster variable was created that represented individuals who were recruited from each site and thus, were nested within a school or the clinic. Effects were allowed to vary by cluster. Due to the analysis of clustered data, analyses employed maximum likelihood estimation with robust standard erorors (ie, MLR). All statistical tests were considered significant when $P < .05$.

RESULTS

Latent class descriptions

An LCA utilizing 6 dichotomous tobacco use indicators (ie, lifetime cigarette, lifetime ECIG, current cigarette, current ECIG, current SLT, and current cigar) indicated that a 4-class solution fit the data well (Table 1). The 4-class solution provided the lowest AIC value, a significant Vuong Lo-Mendal Rubin LRT test, entropy greater than 0.80, and conceptual clarity with sufficient sample sizes.

Figure 1 displays probabilities of endorsing each tobacco use item for each of the 4 latent classes, and Table 2 shows how many participants in each latent class endorsed lifetime and current use of tobacco products. Most participants were classified as *Nonusers* (67.8% of participants). None of the individuals in this class reported lifetime use of cigarettes or current use of any product; however, 15.5% of these individuals reported lifetime ECIG

use. The second largest class was defined as *Cigarette/ECIG Experimenters* (12.5% of participants). Most youth in this class engaged in lifetime use of both cigarettes and ECIGS, but few reported current use of any product. *Current ECIG Users* (11.5% of participants) represented the third largest class; all participants in this class reported lifetime and current ECIG use, almost half reported lifetime cigarette use, and few reported use of other products. For the final class, *Polytobacco Users* (8.1% of participants), all participants reported lifetime use of cigarettes and ECIGs as well as current use of all products. Also among *Polytobacco Users*, nearly half (n = 21; 46.7%) indicated that they currently use 2 products: cigarettes concurrently with ECIGs (n = 11; 50.0%), cigars (n = 3; 13.6%) or SLT (n = 1; 4.6%); or cigars concurrently with ECIGs (n = 4; 18.2%) or SLT (n = 3; 13.6%). One-third (n = 15) of *Polytobacco Users* reported current use of 3 products: cigarettes and ECIGs concurrently with cigars (n = 8; 53.3%) or SLT (n = 2; 13.3%); or SLT and cigars concurrently with ECIGs (n = 4; 26.7%) or cigarettes (n = 1; 6.7%). The remaining *Polytobacco Users* (n = 8; 17.8%) reported current use of all 4 tobacco products.

Associations with latent classes

Table 3 presents descriptive statistics and univariate comparisons for participant characteristics as a function of latent class. *Isolation* scores, sex, and age differed significantly across classes (*P*'s < .05). Post-hoc tests revealed that, for *Isolation*, scores were significantly higher (ie, corresponding with a greater degree of rurality) for *Cigarette/ECIG Experimenters* and *Polytobacco Users* than for *Nonusers*. *Cigarette/ECIG Experimenters* also had significantly higher *Isolation* scores than did *Current ECIG Users*. For sex, the *Polytobacco Users* class included significantly more male participants than were in the *Nonusers* class. For age, *Current ECIG Users* were significantly younger than were *Cigarette/ECIG Experimenters* and *Polytobacco Users*. *Nonusers* were also significantly younger than were *Cigarette/ECIG Experimenters* and *Polytobacco Users*.

Table 4 illustrates the statistical outcomes for multinomial logistic regressions associating participant characteristics with latent class membership. After controlling for participant sex, age, and parental education, individuals with higher geographic *Isolation* scores (corresponding with a higher degree of rurality) were more likely to be *Polytobacco Users* than to be *Current ECIG Users* (OR = 1.61, CI = 1.10, 2.37) and *Nonusers* (OR = 1.51, CI = 1.06, 2.17). Those with higher *Isolation* scores were also more likely to be *Cigarette/ECIG Experimenters* than *Nonusers* (OR = 1.30, CI = 1.09, 1.54).

For sociodemographic covariates, females were less likely to be *Current ECIG Users* (OR = 0.63, CI = 0.39, 1.00) and *Polytobacco Users* (OR = 0.41, CI = 0.23, 0.72) than to be *Nonusers*. Females were also more likely to be *Cigarette/ECIG Experiementers* than *Polytobacco Users* (OR = 2.08, CI = 1.10, 3.93). Older adolescents were more likely to be *Cigarette/ECIG Experimenters* (OR = 1.55, CI = 1.26, 1.90) and *Polytobacco Users* (OR = 1.67, CI = 1.22, 2.30) than to be *Nonusers*. Finally, higher parental education (ie, more parents with a college degree or higher) was associated with reduced odds of being *Current ECIG Users* (OR = 0.52, CI = 0.46, 0.59), *Cigarette/ECIG Experimenters* (OR = 0.39, CI = 0.28, 0.54), and *Polytobacco Users* (OR=0.65, CI=0.37, 1.16) as compared to

being *Nonusers*; lower parental education was also associated with increased odds of being *Polytobacco Users* than *Cigarette/ECIG Experimenters* (OR = 1.69, CI = 0.94, 3.04).

DISCUSSION

The purpose of this study was to classify patterns of adolescent tobacco use and determine whether such classes are associated with geographic rurality as measured by the *Isolation* scale. Tobacco use patterns were determined by LCA, and the classes observed herein mirror those in previous work with adolescents: the largest class was characterized by limited to no tobacco use, the smallest class was characterized by current use of multiple products, and one class appeared to be dominated by ECIG use.[23,34-36] National-level survey data support these patterns, with ~60% of adolescents reporting no current or lifetime use of tobacco products, nearly 30% reporting lifetime polytobacco use, and over 10% reporting current polytobacco use.[37] These same data show that lifetime and current rates of ECIG use have surpassed those even for cigarette smoking[37] and that nearly 64% of current ECIG users report exclusive use of ECIGs.[38] In the current sample, rates of lifetime and current ECIG use (39.0% and 17.7%, respectively) were higher than those for cigarette smoking (25.6% and 7.6%, respectively), and 55% of the *Current ECIG Users* reported no current cigarette smoking. The observed polytobacco use patterns also included primarily use of ECIGs (82.2% of participants) or cigarettes (75.6% of participants), followed by cigars (68.9% of participants) and SLT (42.2% of participants). Most dual product users reported the use of ECIGs and cigarettes (50.0%), and most users of 3 products reported the use of ECIGs, cigarettes, and cigars (53.3%).

Study findings of classes of polytobacco use differed as a function of geographic rurality, with the patterns supporting and extending previous work.[2,16,17] Youth with higher *Isolation* scores were more likely to be *Polytobacco Users* and *Cigarette/ECIG Experimenters* than *Nonusers*, as well as more likely to be *Polytobacco Users* than *Current ECIG Users*. Polytobacco use among adults has been shown to be associated with both rural and urban residence, depending on the types of products used; concurrent use of only traditional products (eg, cigarettes, SLT, and cigars) is more likely among rural residents, whereas the opposite is observed for use of only alternative products (eg, ECIGs and hookah).[16] When these product types are combined, however, differences by geographic area are not observed.[16] Polytobacco use among youth has also been shown to be associated with rural residence.[17] Unfortunately, the specific types of products used concurrently in this youth sample were not reported; however, rates for current use of cigarettes or cigars (~5%-7%) were higher than for ECIGs or SLT (~3% each).[17]

Critically, individuals in classes who are more isolated may be less likely to seek out and utilize health-related resources because the costs to access them are too high. Of course, individuals who access such resources may not be the youth themselves, but rather their parents. Still, the potential negative consequences are likely the same. Youth and adults living in rural communities face not only inadequate health care systems and tobacco control programs, but also lower income levels and fewer transportation options.[6] These tobacco prevention and cessation barriers are exacerbated by the fact that rural areas have long been the target of marketing campaigns and promotions by the tobacco industry.[10,39,40] Indeed,

rural residents report less exposure to antitobacco messages[41] and more exposure to tobacco product advertisements[42] than do their urban counterparts. Therefore, it is not surprising that classes with relatively high levels of lifetime and current use of various tobacco products (ie, *Polytobacco Users* and *Cigarette/ECIG Experimenters*) would be considered more isolated than classes with little history of use (ie, *Nonusers*).

Polytobacco Users also had higher *Isolation* scores than did *Current ECIG Users*. This former class was defined not only by lower levels of current ECIG use, but also higher overall levels of tobacco use, relative to the latter class. These *Isolation* score differences may be due to a myriad of factors. For instance, vape shops may be more heavily concentrated in urban, versus rural, areas,[43,44] and ECIG availability may be more likely in high-, versus low-, income neighborhoods.[45,46] Another possibility is that ECIG use is more common in urban areas where use of other tobacco products is made difficult by stricter clean indoor air policies.[47,48] Future work should consider these factors as potential mediators of the relationship between tobacco use patterns and geographic isolation.

In addition to geographic isolation, classes differed as a function of demographic characteristics in the expected directions. Parental education, which served as a proxy for SES, was higher for *Nonusers* as compared to each of the 3 tobacco use classes. Lower educational attainment (both individual and parental) and/or SES has been associated reliably with higher rates of single[49,50] or polytobacco use[36,51,52] in adolescent and young adult samples. For cigar and ECIG use, results are mixed,[53-55] and perhaps based on whether those sampled also use other tobacco products. Most cigar and ECIG users smoke cigarettes concurrently,[56,57] including in adolescent populations.[55,58] Results for sex differences support findings from the previous literature for use of all tobacco products. Females were at increased odds of being *Nonusers* as compared to *Polytobacco Users* and *Current ECIG Users*. Compared to their female counterparts, males are more likely to engage in single use of all products[12,59-61] and to engage in polytobacco use.[36,62] Also, younger participants were more likely to be *Nonusers* than *Cigarette/ECIG Experimenters*, consistent with work showing that older adolescents report more experimentation and continued use of tobacco products than younger adolescents.[63]

Limitations

Results must be considered in light of study limitations. First, the *Isolation* scale[28] was validated using national-level data and includes scores that range from 0.0 to 12.1, representing a range of the greatest access to virtually no access to health-related resources. In the current study with a regional sample, scores were restricted within the range of 4.5-9.5. Although there was sufficient variability to predict class membership successfully among our sample of adolescents, results should be replicated using nationally representative data with greater variability in scores and a larger sample size. Another limitation involves the YRBS items used to measure certain tobacco products. For instance, items that assess the use of SLT (eg, snuff, chew, and snus) and cigar (eg, large, small, and cigarillo) products are aggregate in nature, preventing the differentiation between more and less traditional product types. These same survey items assessed current, but not lifetime, use of SLT and cigar products. Moreover, the items that assess ECIG use referred to such

devices as “electronic vape products.” While a list of other terms/brands (eg, e-cigarette, vaping pens, Blu, NJOY, and Starbuzz) was provided to help guide respondents, more relevant examples may have been excluded (eg, personal vaporizer and pods)[64] and led to an underestimation of ECIG use.[65] The current study also relied solely on parental education as a proxy for SES. Although we did not assess other SES attributes (eg, parental occupation or income), previous studies show that adolescents’ report of parental education is (1) consistent with parents’ own report of education, (2) significantly associated with parental occupation and income, and (3) a stronger predictor of later developmental outcomes among youth compared to other SES-related attributes.[66,67] Still, future research should consider the role of multiple proxies of SES on adolescents’ tobacco-related outcomes, specifically. Finally, the temporal relation between rurality and tobacco use cannot be established given the cross-sectional nature of this study.

CONCLUSION

The tobacco use landscape in the United States has been in flux over the past few decades, particularly among youth. Their steady decline in cigarette smoking has been overshadowed by their remarkable rates of use of alterative products like hookah and ECIGs, as well as their concurrent use of multiple tobacco products.[68] Moreover, factors that reliably explain the use of cigarettes or other traditional products (eg, SLT) may not hold for use of these latter products. One such factor is geographic rurality, which has historically been associated with high rates of cigarette smoking and SLT use.[1-5] In contrast, the literature is mixed regarding the association between rurality and use of alternative products, whether examined alone or in combination with more traditional ones.[2,17,18] Therefore, the purpose of this study was to examine patterns of traditional and alternative tobacco use as a function of geographic rurality among youth. The continuous *Isolation* scale used in the present study[28] predicted polytobacco use patterns among adolescents in a manner that is consistent with, while simultaneously expanding upon, prior work. Specifically, polyuse of traditional and alternative tobacco products was associated with higher levels of isolation, relative not only to nontobacco users but also those whose use was defined primarily by ECIGs. Given that all classes revealed relatively high rates of ECIG use, more work is needed to elucidate the characteristics that distinguish between ECIG users who do and do not use other tobacco products.

Findings support a recommendation that tobacco intervention efforts should be tailored to different classes of users and that users’ geographic isolation be considered in those efforts.[69,70] In a similar fashion, policy makers could give attention to culturally competent approaches to addressing isolation-related disparities in youth tobacco use. The Centers for Disease Control and Prevention (2014)[71] has stressed the importance of such approaches given the unique needs of rural communities, and recommends working directly with community members to identify the most optimal messages, media campaigns, and policies. More contextually relevant practice and policy efforts will reduce the unfortunate tobacco use disparities in rural youth, thereby enhancing health equity for this most vulnerable population.

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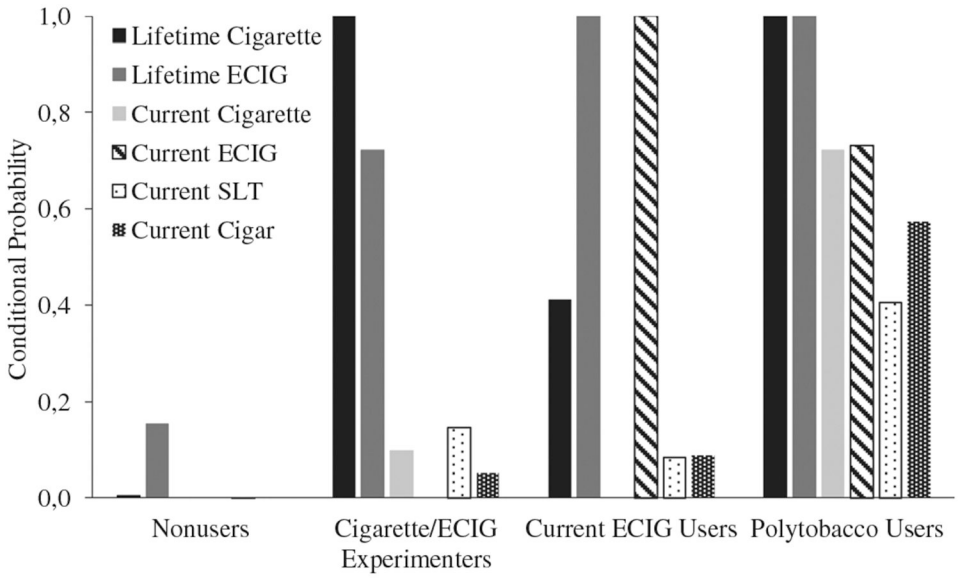

FIGURE 1.
Conditional probabilities of endorsing each tobacco use item for the 4 latent classes

TABLE 1

Fit indices for latent class analyses

Number of classes	AIC	BIC	LRT test *P* value	Entropy	Smallest class (% of sample)
2	2187.242	2243.961	<0.001	0.894	28.97%
3	2118.225	2205.486	<0.001	0.871	12.07%
4	2105.284	2223.086	0.032	0.945	8.10%
5	2113.617	2261.960	0.270	0.960	0.86%

TABLE 2

Tobacco use patterns as a function of latent class membership

	n (%)				
	Full sample (N = 566)	**Nonusers (n = 386)**	**Cigarette/ECIG experimenters (n = 70)**	**Current ECIG users (n = 65)**	**Polytobacco users (n = 45)**
Lifetime cigarette	144 (25.5)	0 (0.0)	70 (100.0)	29 (44.6)	45 (100.0)
Lifetime ECIG	220 (38.9)	60 (15.5)	50 (71.4)	65 (100.0)	45 (100.0)
Current cigarette	43 (7.6)	0 (0.0)	7 (10.0)	0 (0.0)	36 (80.0)
Current ECIG	100 (17.8)	0 (0.0)	0 (0.0)	65 (100.0)	35 (77.8)
Current SLT	36 (6.4)	1 (0.3)	9 (12.9)	7 (10.8)	19 (42.2)
Current cigar	38 (6.7)	0 (0.0)	3 (4.3)	4 (6.2)	31 (68.9)

TABLE 3

Isolation scores and sociodemograhics as a function of latent class membership

	n (%) or *M* (*SD*)					
	Full sample (N = 566)	**Nonusers (n = 386)**	**Cigarette/ECIG experimenters (n = 70)**	**Current ECIG users (n = 65)**	**Polytobacco users (n = 45)**	***P* value**
Isolation score	6.1 (1.1)	5.7 (0.9)	6.4 (1.2)	5.9 (1.1)	6.4 (1.4)	<.001
% Female sex	343 (60.6)	246 (63.6)	43 (61.1)	34 (52.3)	20 (43.5)	.035
Age	16.2 (1.2)	15.7 (1.2)	16.5 (1.2)	16.0 (1.2)	16.6 (1.2)	<.001
% Parents with ≥ college degree						.118
0	165 (29.2)	88 (22.7)	39 (54.2)	25 (38.5)	15 (32.6)	
1	127 (22.4)	77 (20.0)	20 (27.8)	17 (26.2)	13 (28.3)	
2	241 (42.6)	201 (52.0)	10 (13.9)	18 (27.7)	12 (26.1)	

Note. M, mean; SD, standard deviation; *P* values are from one-way ANOVA (*df* = 563) for continuous variables and chi-square tests (*df* = 2) for categorical variables.

TABLE 4

Multivariate associations between Isolation scores, sociodemographic covariates, and latent class membership

		Isolation score	Sex	Age	Parental education
ECIG (vs non)	B (SE), *P* value	−0.06 (0.08), .445	−0.47 (0.29), .042	0.21 (0.10), .036	−0.65 (0.08), <.001
	OR (CI)	0.94 (0.82, 1.08)	0.63 (0.39, 1.00)	1.24 (1.05, 1.47)	0.52 (0.46, 0.59)
Exp (vs non)	B (SE), *P* value	0.26 (0.11), .013	−0.17 (0.46), .714	0.44 (0.13), .001	−0.96 (0.20), <.001
	OR (CI)	1.30 (1.09, 1.54)	0.84 (0.39, 1.81)	1.55 (1.26, 1.90)	0.39 (0.28, 0.54)
Poly (vs non)	B (SE), *P* value	0.42 (0.22), .039	−0.90 (0.35), .009	0.52 (0.19), .007	−0.43 (0.35), .043
	OR (CI)	1.51 (1.06, 2.17)	0.41 (0.23, 0.72)	1.67 (1.22, 2.30)	0.65 (0.37, 1.16)
Exp (vs ECIG)	B (SE), *P* value	0.32 (0.16), .057	0.30 (0.45), .512	0.22 (0.16), .163	−0.31 (0.20), .123
	OR (CI)	1.38 (1.07, 1.78)	1.34 (0.64, 2.82)	1.25 (0.96, 1.62)	0.74 (0.53, 1.02)
Poly (vs ECIG)	B (SE), *P* value	0.48 (0.23), .041	−0.44 (0.46), .342	0.30 (0.22), .163	0.22 (0.32), .485
	OR (CI)	1.61 (1.10, 2.37)	0.65 (0.31, 1.38)	1.35 (0.95, 1.93)	1.25 (0.74, 2.10)
Poly (vs Exp)	B (SE), *P* value	0.16 (0.26), .548	−0.73 (0.39), .046	0.08 (0.20), .699	0.53 (0.36), .039
	OR (CI)	1.17 (0.76, 1.17)	0.48 (0.25, 0.91)	1.08 (0.77, 1.51)	1.69 (0.94, 3.04)

Abbreviations: CI, 95% confidence interval; ECIG, current ECIG users; Exp, cigarette/ECIG experimenters; Non, nonusers; OR, odds ratio; Poly, polytobacco users.

Note. Parental education was entered into models as a continuous variable.